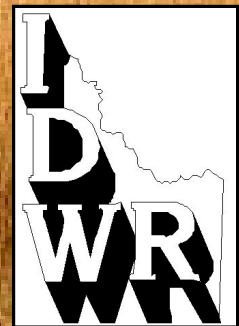


# Temporal Interpolation for Applying METRIC ET to ESPAM.next

ESHMC 12 December 2011



B. Contor, formerly of IWRRI  
E. Rafn, formerly of IDWR



# Basics

*ET depth = (Reference ET depth) x (Crop Coefficient)*

$$ET = ET_r \times K_c$$

# Basics

*ET depth = (Reference ET depth) x (Crop Coefficient)*

*ET depth = ETr x ~~Kc~~ ETrF*

*ET volume = ET depth x Area*

# Basics

Today's discussion

*ET depth = (Reference ET depth) x (Crop Coefficient)*

*ET depth = ETr x ~~Kc~~ ETrF*

~~*ET volume = ET depth x Area*~~

Not today's discussion

# Basics

$ET$  (Coefficient) Actually *this* is today's discussion

$ET \text{ depth} = ETr \times$   ~~$Kc$~~   $ETrF$

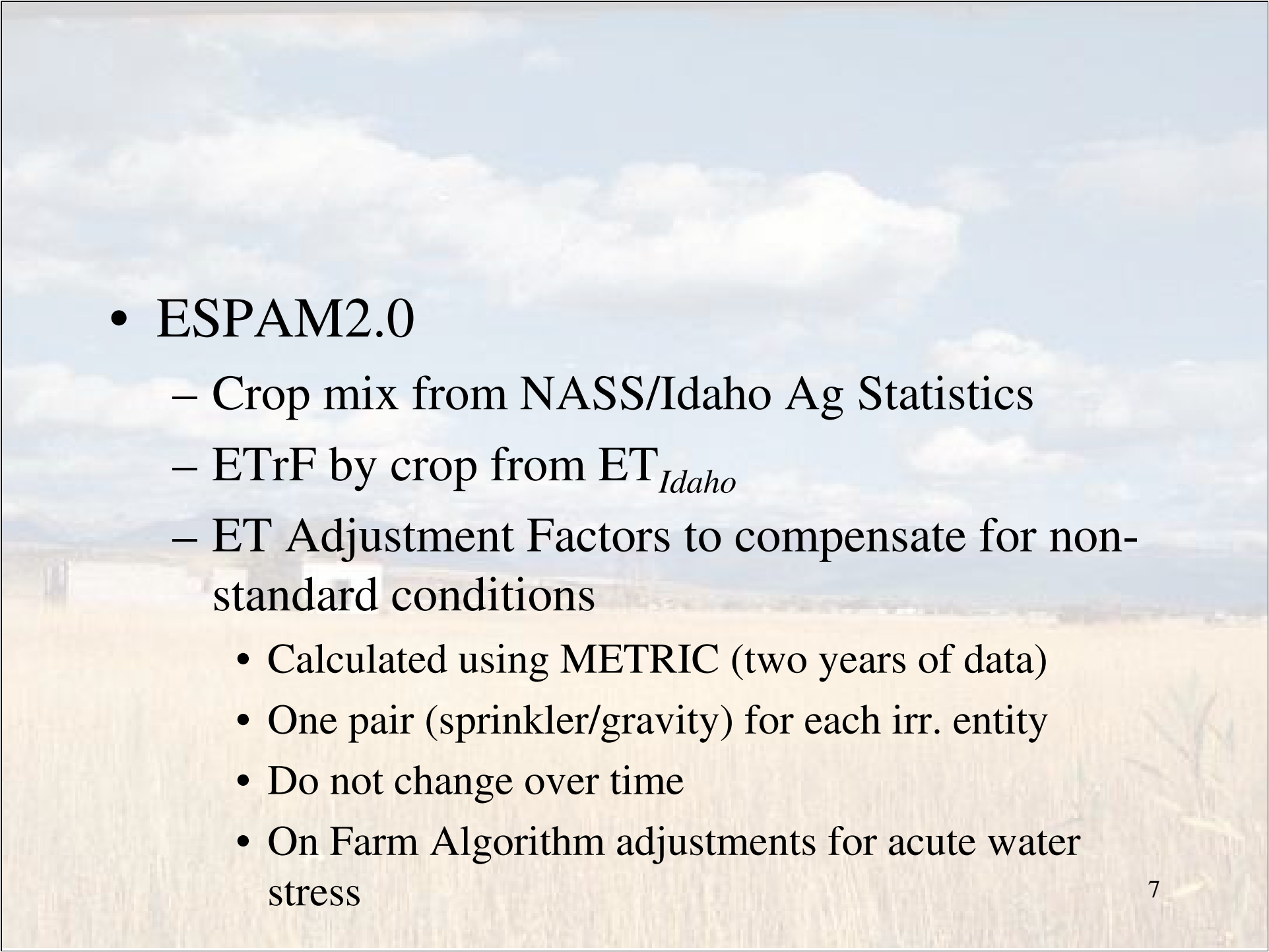
~~$ET \text{ volume} = ET \text{ depth} \times Area$~~

Not today's discussion

**We are talking only about ETrF (Kc) Today**

# Past ESPAM Practice for ET<sub>TrF</sub>/K<sub>c</sub>

- ESPAM1.1
  - Crop mix from NASS/Idaho Ag Statistics
  - ET<sub>TrF</sub> by crop from ET<sub>Idaho</sub>
  - ET Adjustment Factors to compensate for non-standard conditions
    - Set by professional judgement
    - Confirmed by METRIC (one year of data)
    - One pair (sprinkler/gravity) for entire study area
    - Did not change over time
    - Ad Hoc manual adjustments for acute water stress

- 
- ESPAM2.0
    - Crop mix from NASS/Idaho Ag Statistics
    - ETrF by crop from  $ET_{Idaho}$
    - ET Adjustment Factors to compensate for non-standard conditions
      - Calculated using METRIC (two years of data)
      - One pair (sprinkler/gravity) for each irr. entity
      - Do not change over time
      - On Farm Algorithm adjustments for acute water stress

# Why Metric is Attractive

- 30 meter to 60 meter pixels (instead of whole counties)
- Implicitly reflects
  - crop mix
  - stress (moisture or other)
  - variations in varieties or methods
  - non-irrigated inclusions
- Some compensation for imprecision in irrigated lands data

# Why Temporal Interpolation?

- METRIC ETrF values won't ever be available for all years
  - Clouds
  - Weather data for calibration  
*(remember the “IC” in METRIC stands for “Internal Calibration”)*

# How to Interpolate?

- Naïve method
  - Assume some other year's METRIC ETrF/Kc values are pretty good for this year
- Direct Calculation of ETrF/Kc from NDVI (Normalized Difference Vegetative Index)
- Use NDVI to constrain application of other year's METRIC (NDVI Scaling)

# Calculate Kc From NDVI

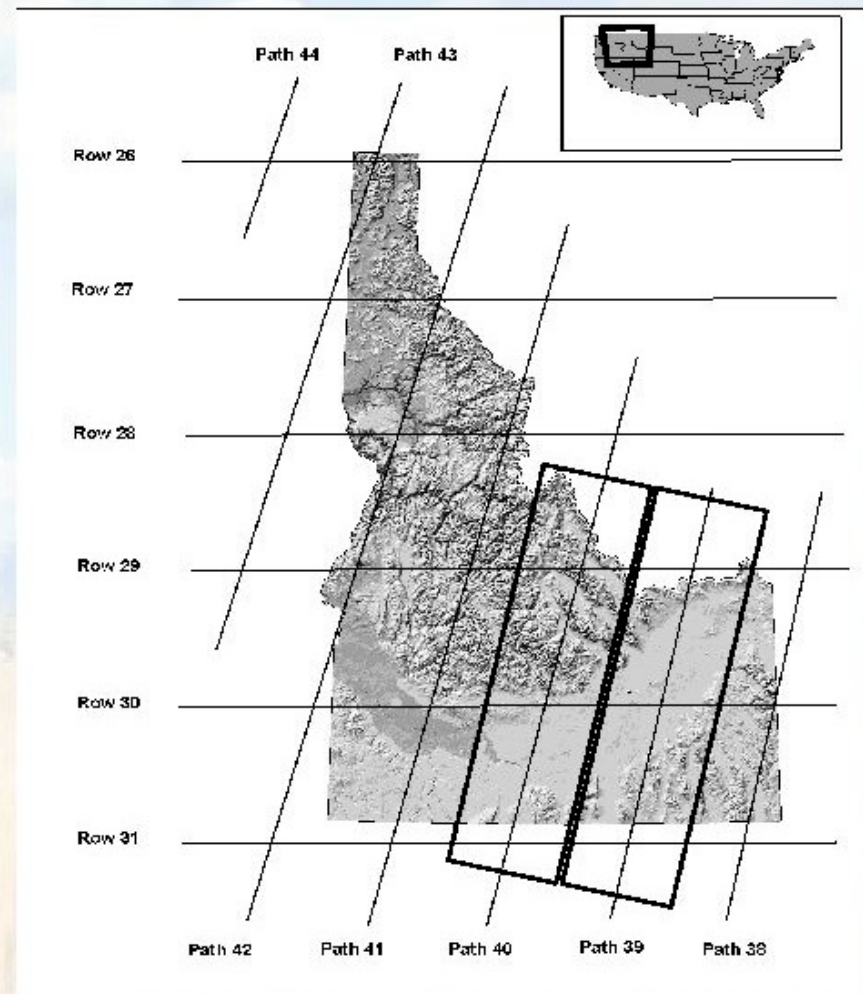
- Obtain Kc values from METRIC or other crop coefficient data sources.
- Use remote sensing to calculate NDVI values.
- Create equations to relate Kc and NDVI.

For example:

$$K_c = 1.1875 * NDVI + 0.05$$

# Statistical Test Results

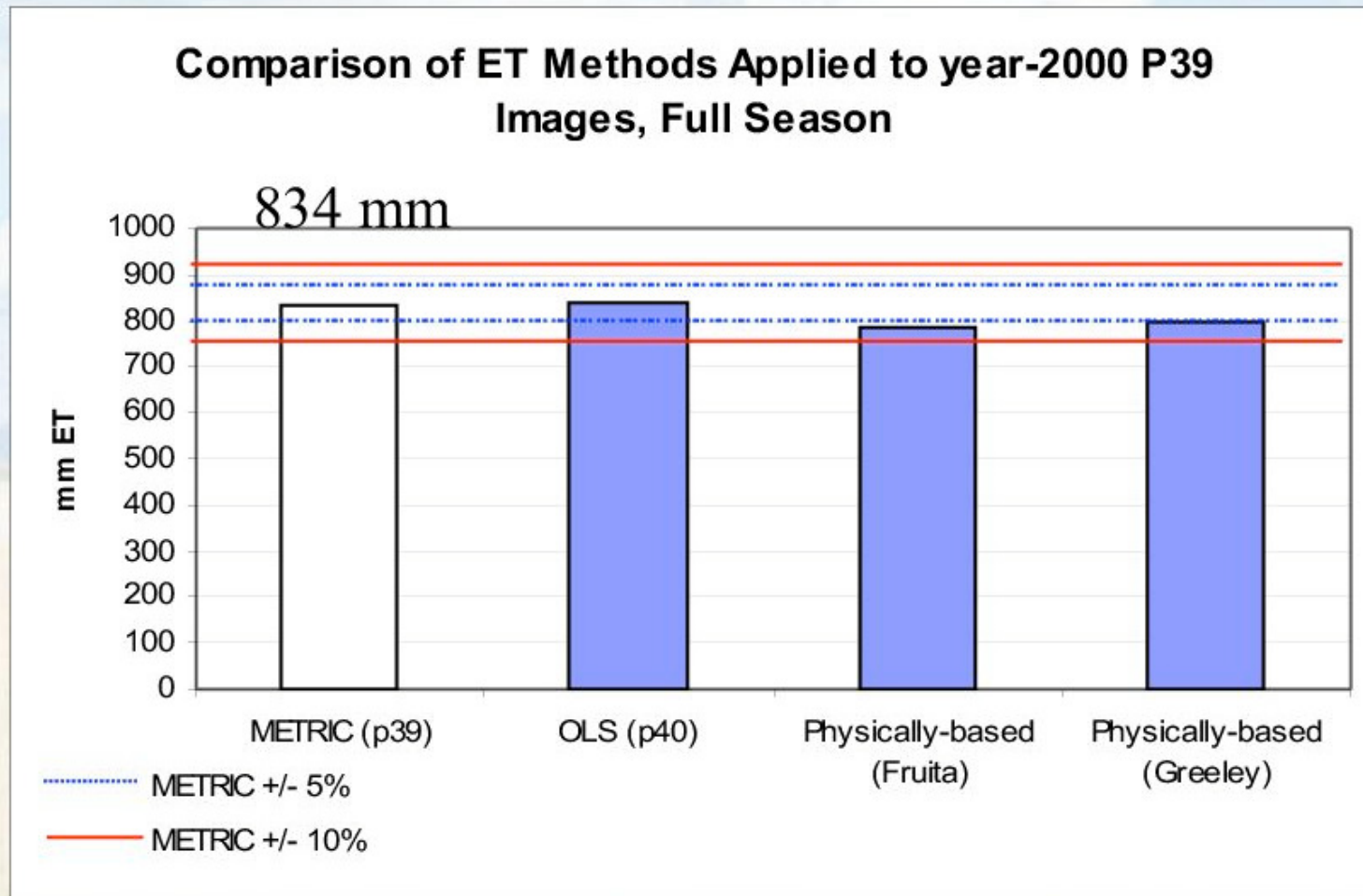
- Used Kc equations for:
  - path 40 (p40) study area.
  - path 39 (p39) study area.
- Compared statistically and found the equations are not statistically equivalent.



# Practical Test Results

- Used three NDVI/Kc equations (p40, Fruita and Greeley Colorado) to calculate Kc for p39.
- Used ETref and Kc to calculate ET depth for p39.
- Compared ET depths with METRIC ET depths.

# Practical Test Results, cont'd



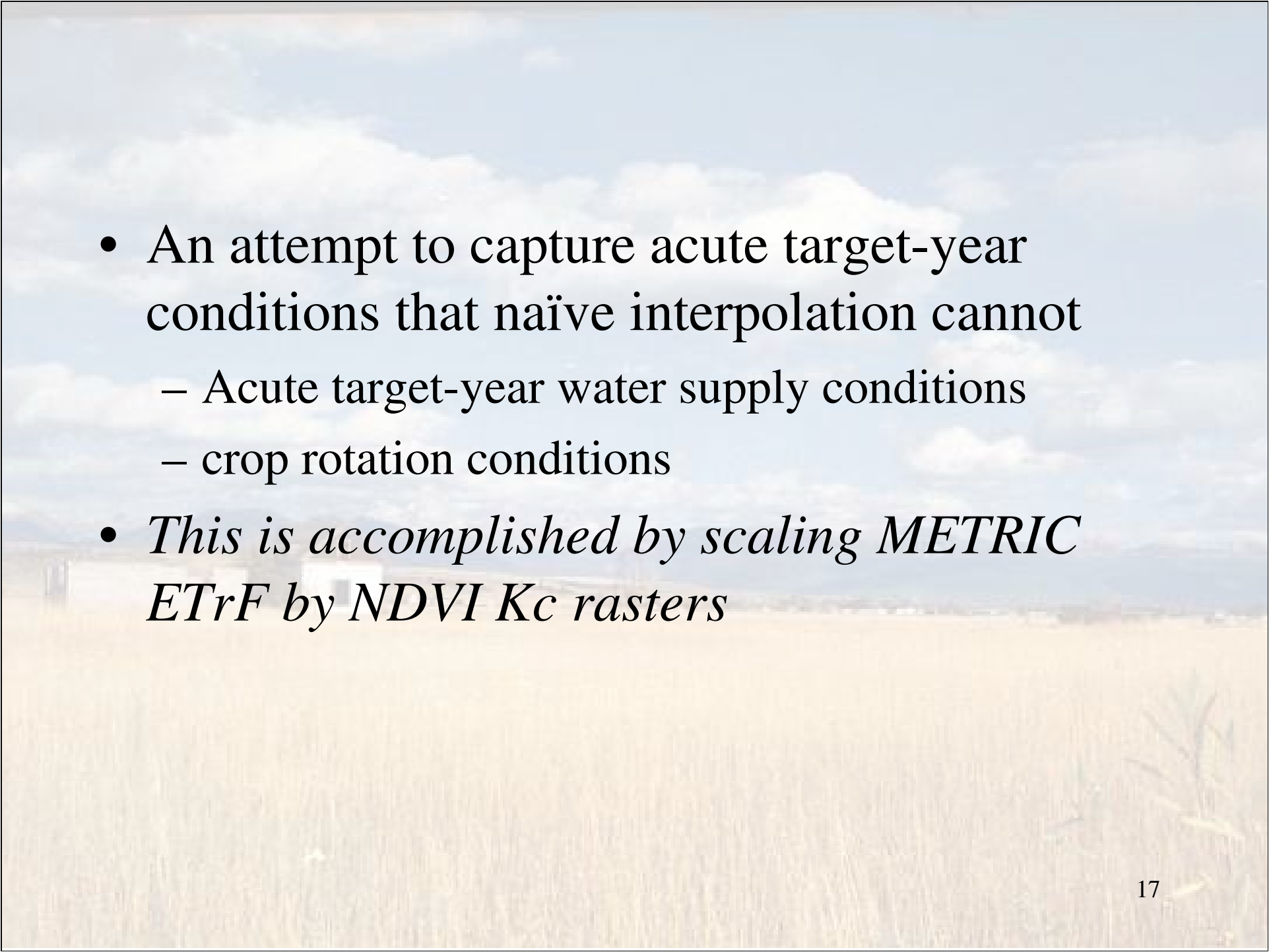
# Temporal Applicability

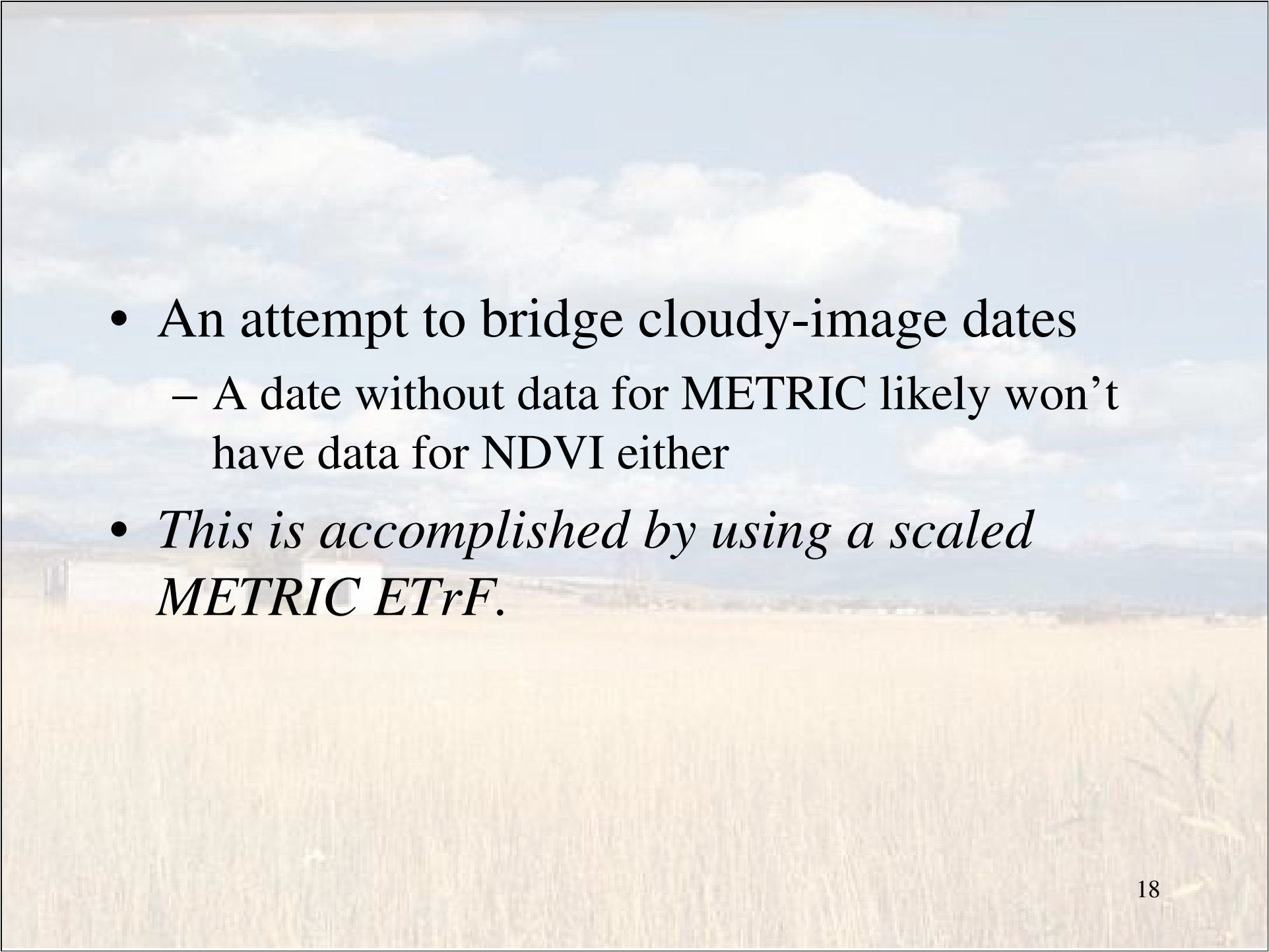
Regarding full-season ET estimation:

- Tasumi et al. (2006) reports that NDVI/Kc equations developed in 1989 produced good results for the same location when applied to Year 2000 data.
- We similarly found that NDVI/Kc equations developed in 1989 in Colorado produced good results when applied to Year 2000 (p39) data.

# NDVI Scaling Method

- An attempt to capture the theoretical advantages of METRIC
  - Evaporation from bare soil
  - Crops with a full canopy but some agronomic stress (moisture or other)
  - Crops that have similar leaf area but different vigor or agronomic characteristics
- *This is accomplished by using other-year METRIC ETrF rasters*

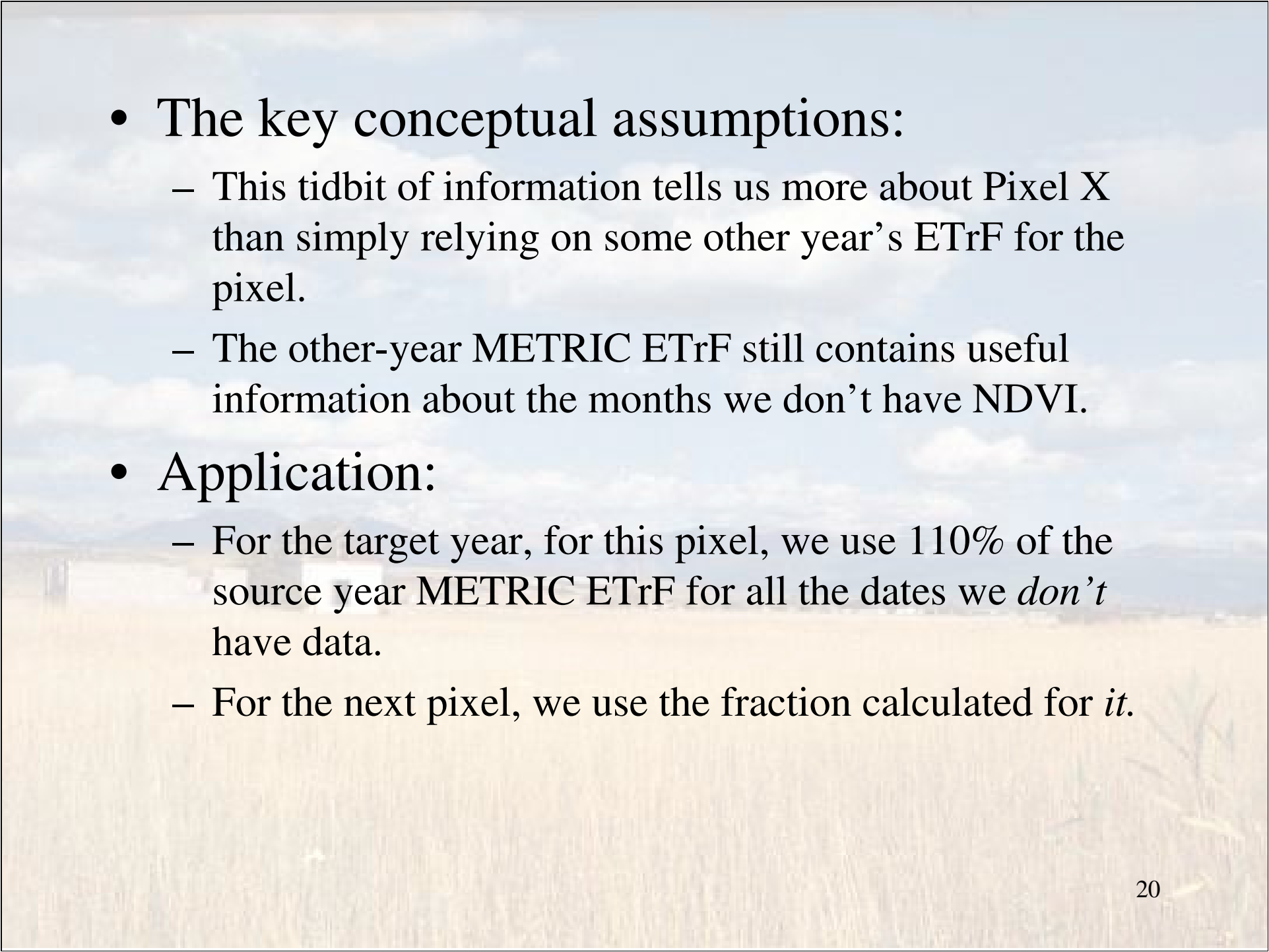
- 
- An attempt to capture acute target-year conditions that naïve interpolation cannot
    - Acute target-year water supply conditions
    - crop rotation conditions
  - *This is accomplished by scaling METRIC ETrF by NDVI Kc rasters*

- 
- An attempt to bridge cloudy-image dates
    - A date without data for METRIC likely won't have data for NDVI either
  - *This is accomplished by using a scaled METRIC ETrF.*

# Simple conceptual explanation:

- Suppose for the dates I have data, Pixel X has an NDVI-derived  $K_c$  from the target year, which is 110% of the METRIC ETrF from the source year
  - Maybe there is better water supply
  - Maybe this is alfalfa and it used
  - Maybe farmer Tom has retired and farmer Sally takes better care of the place

***BLUNDER!***  
*See addendum  
slides at end.*

- 
- The key conceptual assumptions:
    - This tidbit of information tells us more about Pixel X than simply relying on some other year's ETrF for the pixel.
    - The other-year METRIC ETrF still contains useful information about the months we don't have NDVI.
  - Application:
    - For the target year, for this pixel, we use 110% of the source year METRIC ETrF for all the dates we *don't* have data.
    - For the next pixel, we use the fraction calculated for *it*.

# The Test

- Assume 2006 METRIC is the Gospel Truth
  - Use 2002 METRIC ETrF and various 2006 NDVI Kc data to calculate 2006 Estimates
    - In our nomenclature 2002 is the “source”
    - 2006 is the “target”
    - Obviously if we had data for METRIC for 2006 we would use it, but here we assume for test purposes that some data are missing
  - Methods are evaluated by how they compare to year-2006 METRIC

- *Reality check*

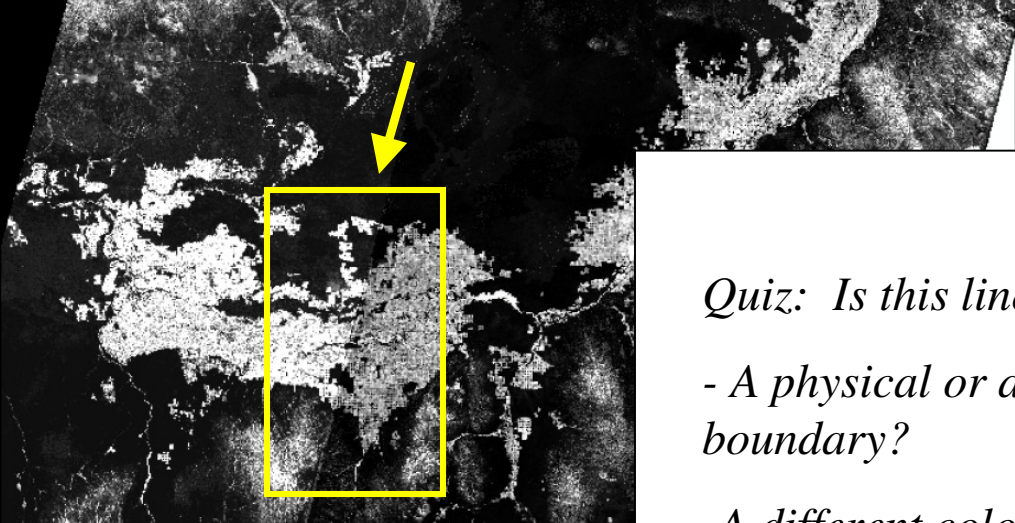


Figure 1. Path 39 and 40 Year-2000 METRIC ET on the Snake  
highest values of ET.

Because the non-irrigated parcels adjacent to irrigated lands are  
irrigation entities, we could not perform calculations for out-of-  
applying Equation (3) concept to obtain preliminary by-entity fa  
concept to all irrigated lands plus a 70-meter buffer to obtain a global coefficient. Figure 2 shows the

Quiz: *Is this linear feature:*

- *A physical or administrative boundary?*
- *A different color ramp between images?*
- *A difference in P39 and P40 METRIC for the same year?*

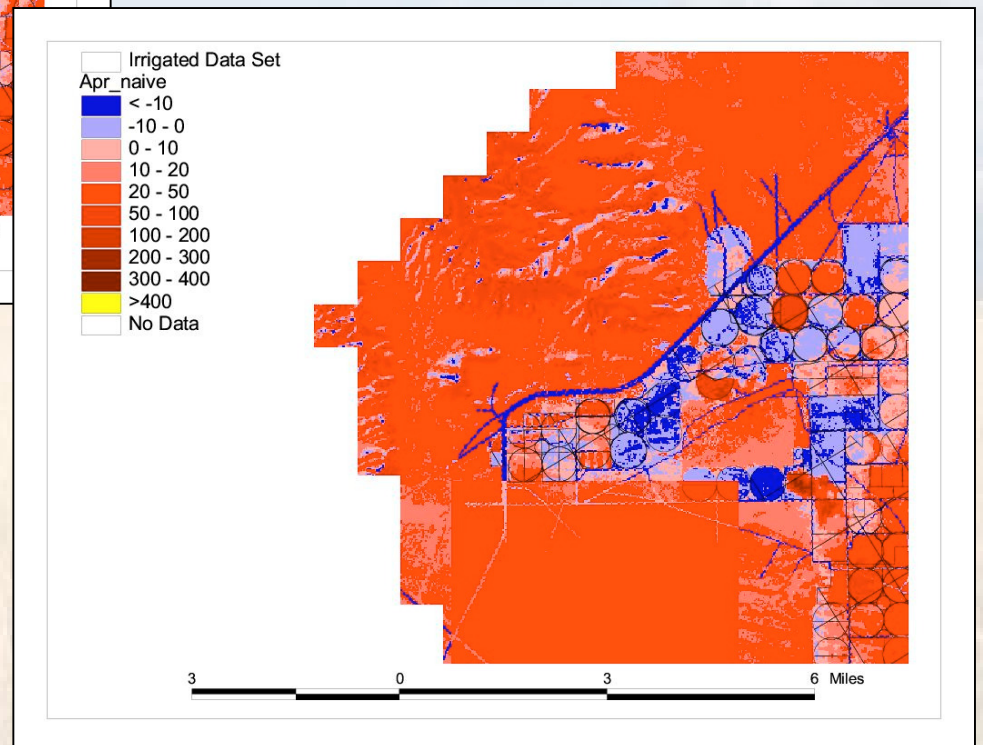
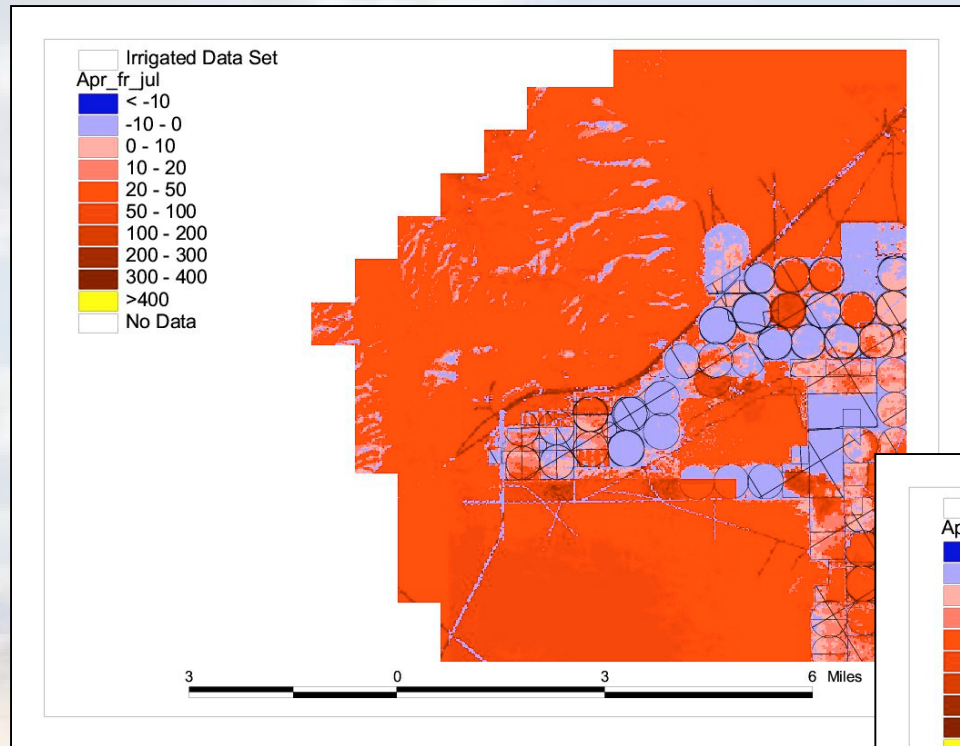
# Steps

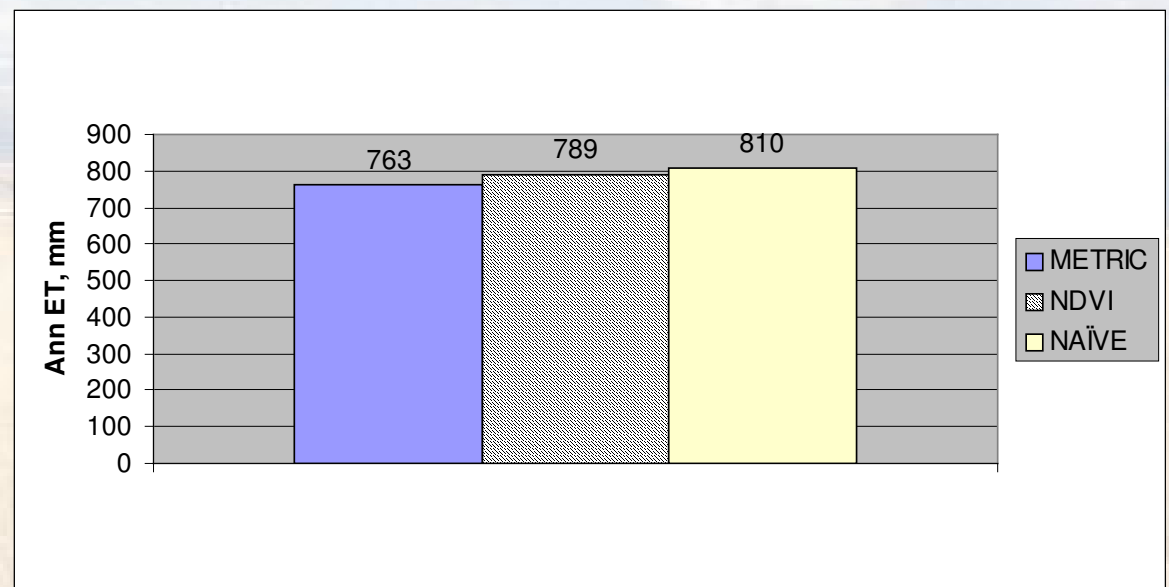
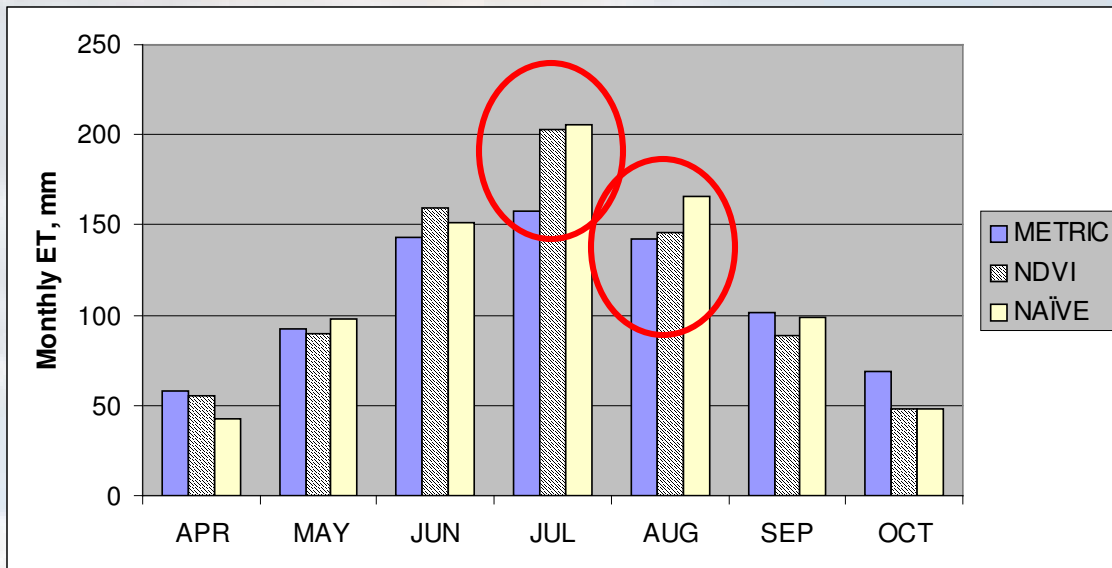
- Apply the Naïve method and calculate average ET depth
- Apply the NDVI Scaling method and calculate average ET depth for 7 summer months
  - Assume 5 months data will be available (2 tests)
  - Assume 3 months data (2 tests)
  - Assume only one month data (4 tests)

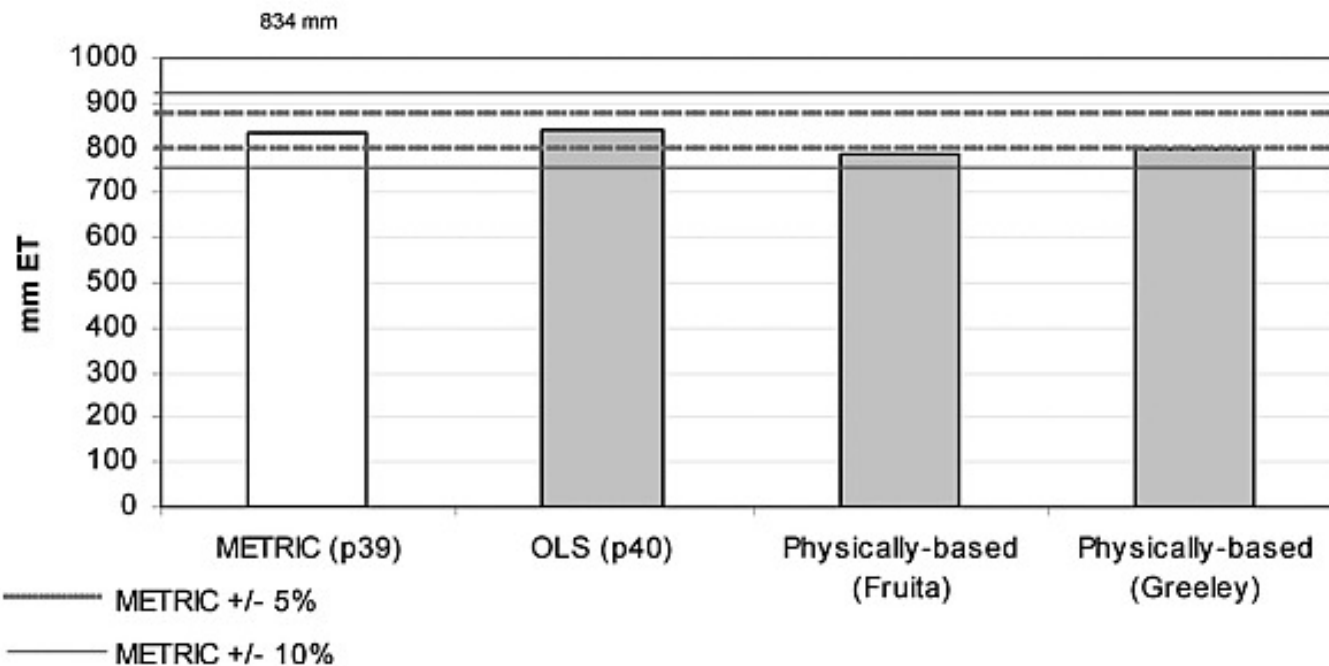
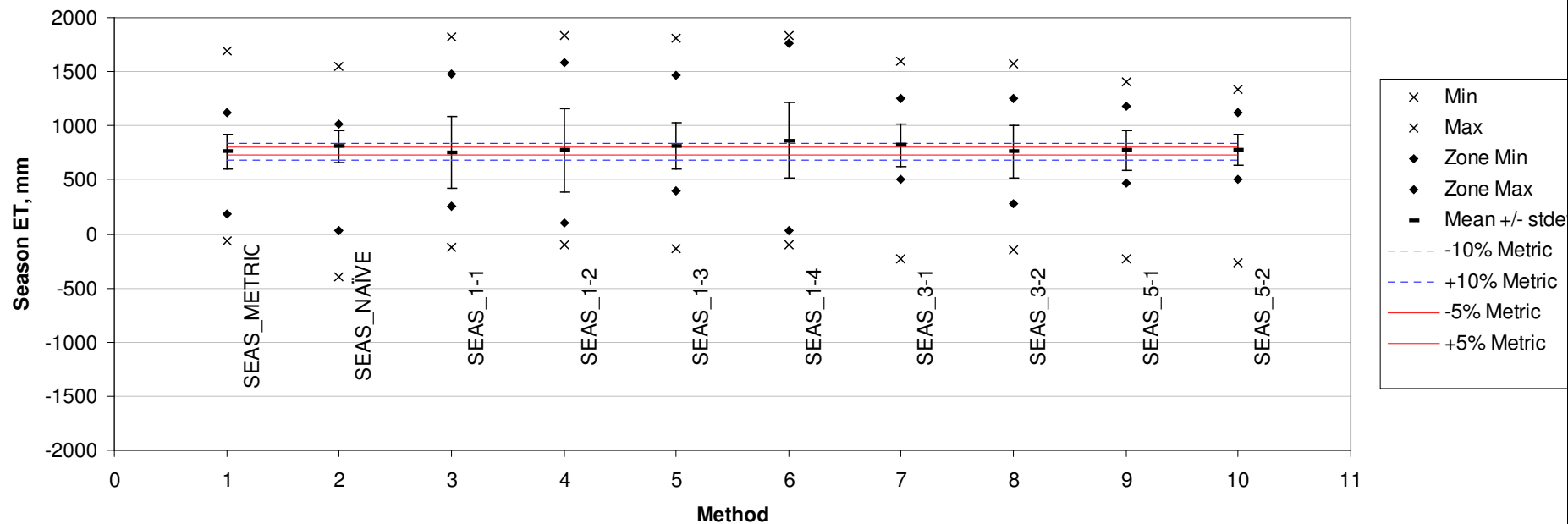
# Steps

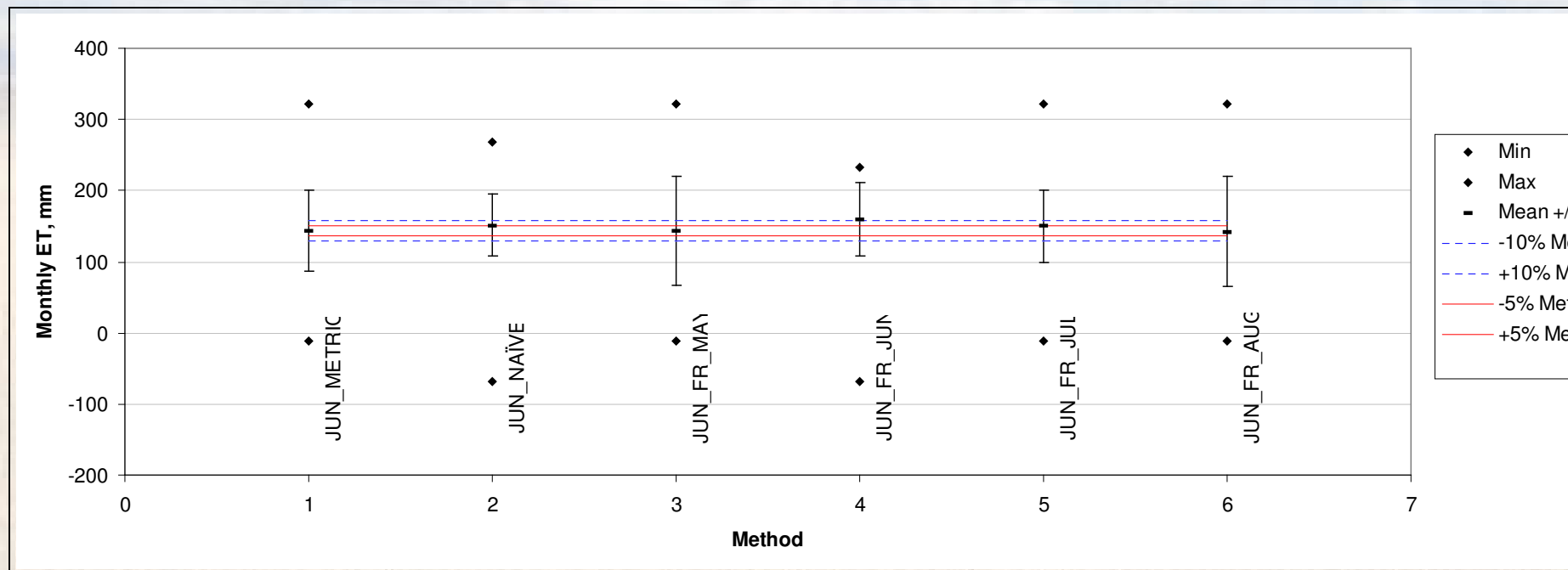
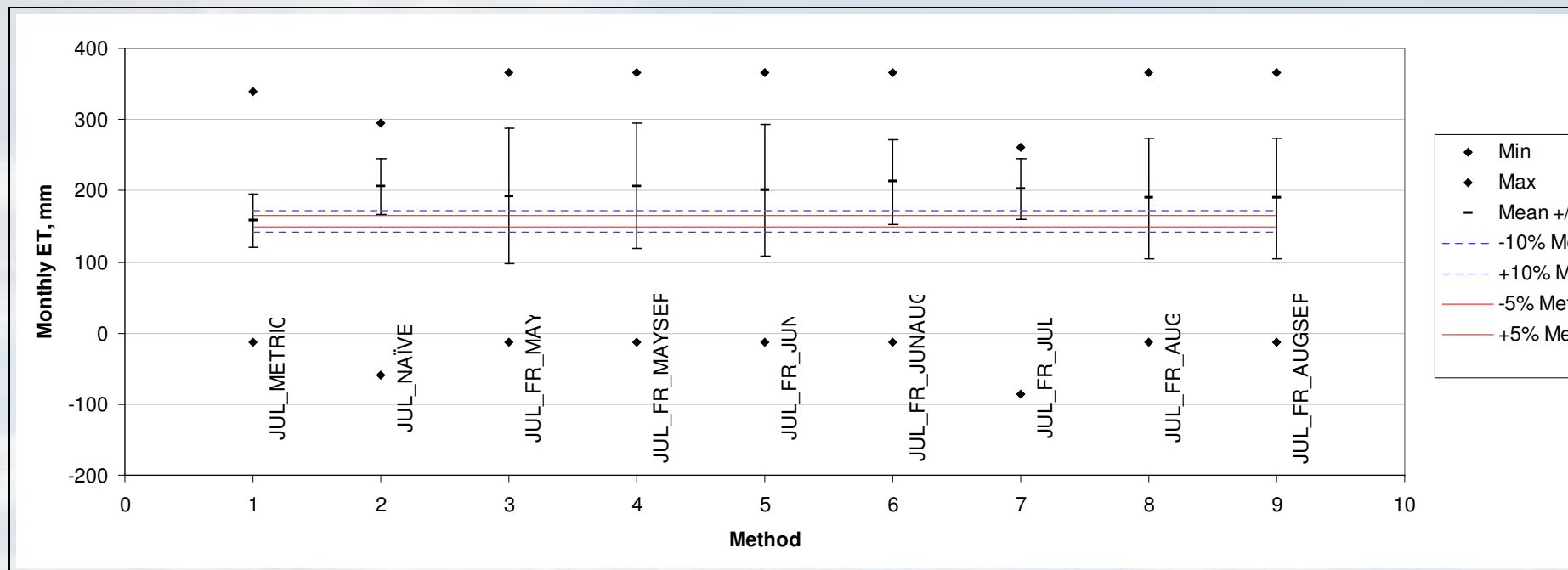
- Compare the results to 2006 METRIC ET depth
  - I said “we’re only talking about  $E_{TrF}/K_c$ ”
  - However, we used ET depth to weight the scoring
    - A big error on  $E_{TrF}/K_c$  in April when ET is low may be trivial
    - A small error in July when ET is high may be problematic

# Interesting Results







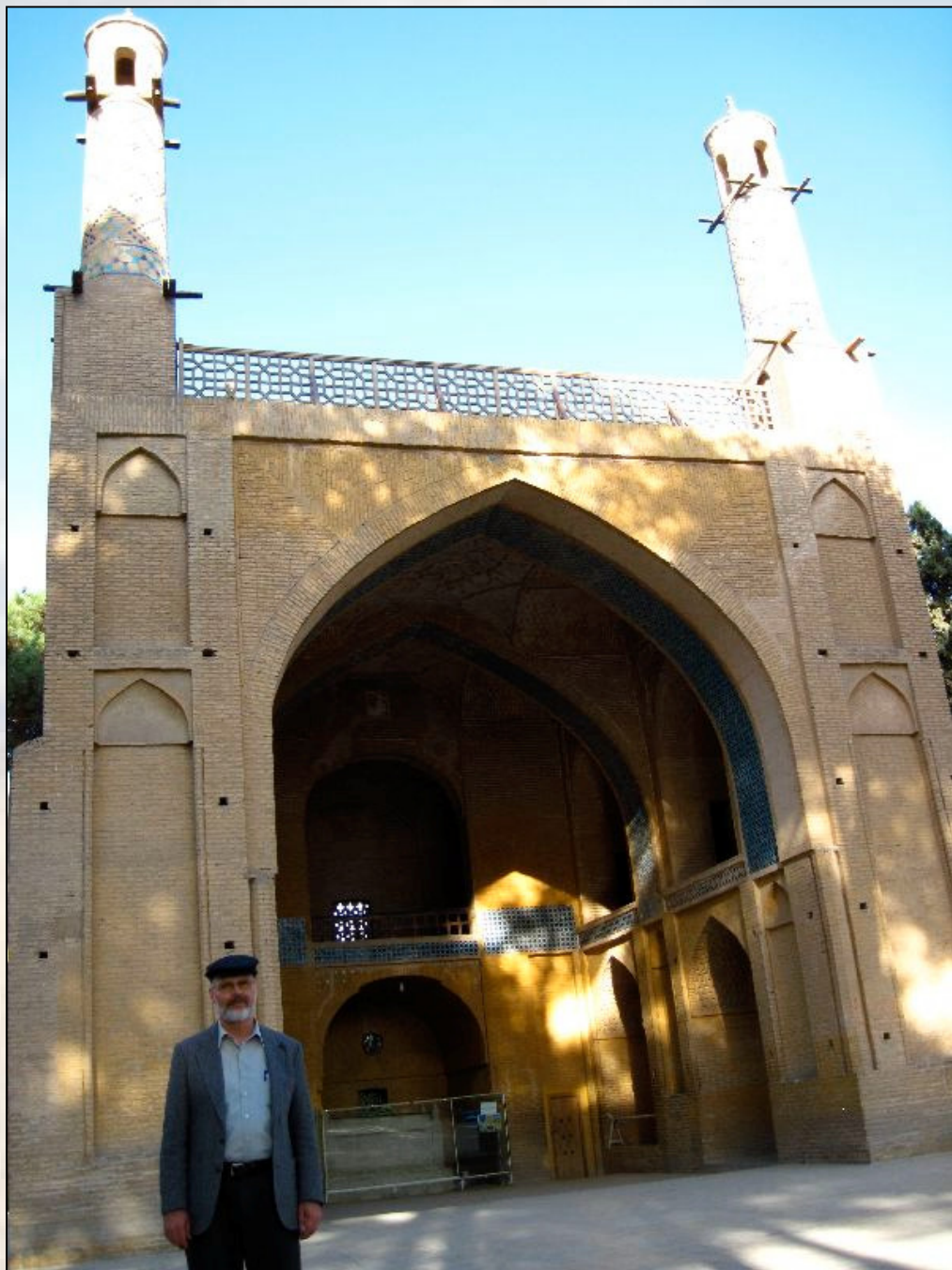


# Recommendations

- Use METRIC for all years it is available
- Interpolate between METRIC images for intervening years
  - Use NDVI Scaling method if even one month of NDVI data are available
  - Use Naïve method otherwise
- Extrapolate 1986 METRIC to earlier years
  - Same NDVI/Naïve criteria as interpolation

# Other Options to Consider

- Use SEBAL for 1982 - 1985
  - doesn't require weather data for internal calibration
- Use an average of METRIC years instead of a single year.
- Use NDVI directly w/o scaling (*when enough data*).
- Use NDVI scaling for months near the month of an NDVI image, Naïve for months distant (*but remember what we saw w/ “July from Jun/Aug”*).



# Addendum

- The rest of the slides were added after presentation to the ESHMC. They show the blunder and proposed correction that were discussed in the meeting.

*Slide 19 as shown  
in ESHMC  
meeting*

## conceptual explanation:

- Suppose for the dates I have data, Pixel X has an NDVI-derived  $K_c$  from the target year, which is 110% of the METRIC  $ET_{rF}$  from the source year
  - Maybe there is better water supply
  - Maybe this is alfalfa and it used to be barley
  - Maybe farmer Tom has retired and farmer Sally takes better care of the place

*Corrected slide*

## conceptual explanation:

- Suppose for the dates I have data, Pixel X has an NDVI-derived  $K_c$  from the target year, which is 110% of the ~~METRIC-ET<sub>r</sub>F~~ **NDVI  $K_c$**  from the source year
  - Maybe there is better water supply
  - Maybe this is alfalfa and it used to be barley
  - Maybe farmer Tom has retired and farmer Sally takes better care of the place

# Discussion

- The original plan was to scale source year METRIC ETrF values by a number that reflected differences between the source year and target year.
- The corrected slide (slide 35) accomplishes this by using the ratio of  $(\text{Target NDVI Kc}) / (\text{Source NDVI Kc})$  which truly will capture only year-to-year differences.

- The problem with Slide 19 formulation  $(\text{Target NDVI Kc}) / (\text{Source METRIC ETrF})$  is that it would incorporate *both* year-to-year differences *and* differences between METRIC and NDVI methods.
- Applying this flawed ratio would have the tendency of removing any advantage METRIC had over NDVI, biasing the results towards the expected NDVI result.

# IWRRI Commitments

- Deliver revised slides that note the blunder and commitments (these slides).
- Repeat the analysis using the correct formulation of the ratio.
- Incorporate the revision into the draft report and re-submit to IDWR for review.
- Clarify the alleged advantages of the METRIC over ESPAM1.1/ESPAM2.0.
  - Will be addressed in the report.